Cloud Robotics Applications with Virtual Fort Knox

Christian Henkel, Fraunhofer IPA
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A Quick Intro – Cloud Robotics
Outline

1. Virtual Fort Knox Platform
2. Manufacturing Service Bus
3. Use Cases
Outline

1. Virtual Fort Knox Platform
2. Manufacturing Service Bus
3. Use Cases

- Communities
- Independent Service Vendors
- Platform Operator
- Devices
- VFK Marketplace
- VFK SDK
- Aggregated Services
- Services
- Integration Services
- Smart Objects
- (Equipment & CP/P)S
- Basic Services
- Research
- Virtual Fort Knox
Components and Roles

- Devices
- VFK Marketplace
- VFK SDK
- End-User
- Communities
- Independent Service Vendors
- Platform Operator
- Basic Services
- Aggregated Services
- Integration Services
- Smart Objects (Equipment & CP(S))
- Service Bus Manufacturing

Research Virtual Fort Knox
Manufacturing Software today – as you require it

<table>
<thead>
<tr>
<th>OPEN</th>
<th>EFFICIENT</th>
<th>SECURE</th>
<th>CONNECTED</th>
<th>ON DEMAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>flexibility</td>
<td>time</td>
<td>trust</td>
<td>location</td>
<td>cost</td>
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### Virtual Fort Knox Benefits

<table>
<thead>
<tr>
<th>Description</th>
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<tbody>
<tr>
<td>We provide open access to our platform and our core components are available as open source.</td>
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<tr>
<td>We enable easy integration of services and smart object by various vendors based on standards.</td>
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<tr>
<td>We ensure business continuity and high data protection with our Private/Hybrid Cloud solutions.</td>
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<td>We support data-driven production control by easy accessing information from various sources.</td>
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<tr>
<td>We use cloud technologies to enable fast deployment and variable cost.</td>
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VFK Fraunhofer PRODUCTION

- Fraunhofer rolled out VFK platform to 7 Institutes of the FhG-Production-Cluster
- 1.7 Mio. Invest in Infrastructure
VFK Hybrid Cloud Solution – Fraunhofer Implementation

Distributed Marketplace Synchronisation

IFF (Magdeburg)
IEM (Paderborn)
IPT (Aachen)
IPK (Berlin)
IWU (Chemnitz)
IGCV (Augsburg)
IPA (Stuttgart)
Outline

1. Virtual Fort Knox Platform
2. Manufacturing Service Bus
3. Use Cases
Concept
Connection Establishment

Manufacturing Service Bus

(1) Register
(2) Throw Event
(3) Handle Callback

Broker

Common Interface

Smart Object/Application

Client
# Client Libraries Overview

<table>
<thead>
<tr>
<th>Common Interface</th>
<th>Programming language</th>
<th>State</th>
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</thead>
<tbody>
<tr>
<td>Client Libraries</td>
<td>Java</td>
<td>Ready</td>
</tr>
<tr>
<td></td>
<td>C#</td>
<td>Ready</td>
</tr>
<tr>
<td></td>
<td>C++</td>
<td>Re-Implementation</td>
</tr>
<tr>
<td></td>
<td>Python</td>
<td>Ready</td>
</tr>
<tr>
<td></td>
<td>Node.js</td>
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<td>Node.js</td>
<td>Ready</td>
</tr>
<tr>
<td>Test Clients</td>
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<tr>
<td></td>
<td>ROS (Robot Operating System)</td>
<td>Ready</td>
</tr>
<tr>
<td></td>
<td>CloudPlug (Gateway for OPC-UA Server, CAM, …)</td>
<td>Ready</td>
</tr>
<tr>
<td></td>
<td>Field Busses (EtherCAT, Powerlink, …)</td>
<td>In Development</td>
</tr>
</tbody>
</table>
Benefits for ROS users

Market for robotics services
- Offer Services
- Find Customer
- Flexible Business Models

Run ROS multi-master systems
- Before ROS2
- Authentication

Define communication at runtime
- Usability
- Flexibility

Interface automation equipment
- PLC
- Sensors
- MES / ERP Systems
Outline

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Cloud Navigation
Cloud Navigation Architecture

Sensor Upgrade *as a Service*
Example for Service-oriented Business Models

Robot can not perceive the obstacle
Will only replan if obstacle is in sight

External sensor can perceive the obstacle
Robot will immediately replan
SuperCaps in AGVs
Autonomous Guided Vehicles
Supercapacitor equipped AGVs

Traditional Batteries
High Capacity
Long Charging
Idle times while charging
Unused capital (AVGs)

Supercapacitors
Medium Capacity
Fast Charging
Can charge in transfer times
Idle times occurring anyway
Cloud-based Charging Control
Supercapacitor equipped AGVs

Cloud Server
- Monitoring state of charge
- Control of charging stations
- Energy Optimization
- Intelligent planning of charge times
- Integration with production control

Smart Objects
AGVs

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Charge-Level-Aware Task Allocation
Supercapacitor equipped AGVs

Manufacturing Station
Transport Task
AGV
Manufacturing Station with Charging
Edge Computing in Automation
Edge Computing in Automation
Efficient distribution and update of software on the shopfloor

Cloud Computing

Edge Computing

Deployment

Computation

Sensors

Data

Actuators

Computation

Sensors

Data

Actuators
Edge Computing in Automation
Efficient distribution and update of software on the shopfloor

- Computation moves from cloud to hardware
- Deployment and update from cloud
  - Fast and secure communication
  - Low effort for update
  - Data Processing where Data ‘happens’
  - vs Conventional Computation
Outline

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Outlook

Future Things I plan on doing regarding ..
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